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BLACK-TAILED PRAIRIE DOG COLONY DYNAMICS IN SOUTH DAKOTA OVER A 10-YEAR PERIOD

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Abstract: Between 1968 and 1978, aerial photography was used to monitor distribution of black-tailed prairie dog (*Cynomys ludovicianus*) colonies on a 400-square mile area in South Dakota, including parts of Buffalo Gap National Grassland, Pine Ridge Indian Reservation, and Badlands National Monument (now Badlands National Park). Aerial photographs were taken of the study area in 1968 and annually from 1974 through 1978 at a scale of 1:20,000 (1968) and 1:15,840 (1974-1978). Prairie dog colonies were identified on the photographs, outlined, and the outline transferred to USGS topographic maps for colony size measurements. This technique reliably detected changes in prairie dog colony numbers, size and distribution. Although there was limited use of prairie dog rodenticides early in the study, the land area occupied by prairie dog colonies increased by approximately 28.4% over the 10-year period. Between 1968 and 1974 area occupied by prairie dog colonies increased from 1154 ha (1.4% of the area) to 5890 ha (7.1%). By 1978, prairie dog colonies occupied 14023 ha (16.9% of the area). The number of colonies increased from 110 in 1968 to 344 in 1974 and 508 in 1978, with many colonies being assimilated during colony expansion. Prairie dog colony expansion rates were significantly lower on the Badlands National Monument (BNM) than on the Buffalo Gap National Grasslands, private lands, and Pine Ridge Indian Reservation. The BNM is ungrazed by livestock (cattle), while most other rangelands in the study are a grazed annually by livestock at moderate to high stocking rates. Standing vegetation around prairie dog colonies in the National Monument was noticeably greater than around colonies elsewhere in the study area, suggesting that vegetation impacts from annual livestock grazing significantly increased colony expansion rates outside the BNM. Modifications to the grazing regime may improve rangeland condition, particularly during drought years when the rangeland is under stress, and could slow or eliminate prairie dog colony expansion.

Key words: Badlands National Monument, Buffalo Gap National Grassland, colony expansion, *Cynomys ludovicianus*, grazing, prairie dogs, South Dakota

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INTRODUCTION

We conducted a definitive study of the

changes in colony numbers, size, and distribution over a ten-year period (1968-1978) in South Dakota. The purpose of the study was to determine prairie dog colony expansion rates to assist in management planning and help define the extent of management required to maintain colonies at levels consistent with the balanced use of all rangeland resources.

This study had three objectives: (1) to determine if panchromatic vertical imagery provided a reasonably accurate format for plotting black-tailed prairie dog colony numbers, size, and distribution; (2) to describe annual trends in colony numbers, size, and spatial distribution; and (3) to compare colony expansion rate on two major land divisions with and without livestock grazing.

This study was conducted under the guidance of the U.S. Fish and Wildlife Service, Department of the Interior. The National Wildlife Research Center transferred to the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) on December 19, 1985.

METHODS

Study Area

The study area is located in Custer, Pennington, Shannon, Jackson, and Washabaugh Counties in southwestern South Dakota. It consists of a 103,707 ha rectangle including portions of the Buffalo Gap National Grassland (40,000 ha), Pine Ridge Indian Reservation (18,500) and Badlands National Monument (25,222 ha) (Figure 1). There is an additional 20,000 ha of private land in the study area. Livestock graze the national grassland, intermingled private lands, and Indian reservation at moderate to high stocking rates (Livestock Grazing Complex) and data from these land divisions are lumped. The portions of the national monument in the study area are grazed only by wildlife and occasionally by a small number of bison. For the purpose of this manuscript the BNM is labeled “ungrazed” and the Livestock Grazing Complex is labeled “grazed”.

A limited amount of rodenticide use to reduce prairie dog populations occurred on those portions of the study area outside the national monument from 1968 through 1971. In 1972, further use of pesticides that were potentially hazardous to nontarget wildlife was halted on public lands by Presidential Executive Order No. ll643. Legal use of rodenticide (2% zinc phosphide) to reduce prairie dog populations did not resume in the study area until the fall of 1978. At the time of this study, prairie dog colonies in the study area were not influenced by plague epizootics.

The study area is characterized by two major land forms: precipitous clay and shale-based badlands that form a crescent-shaped wall to the west, north, and east, and a flat to gently rolling grassland extending southward to a well-defined ridge south of the White River, the common boundary with Pine Ridge Indian Reservation (Figure 1). The topographic characteristics form a natural bowl in the Grassland called "The Conata Basin" in the center of the study area. Elevations range from 702 m along the White River bottoms to a maximum of 915 m along the north-central badlands escarpment. The area is drained by a complex of intermittent channels flowing south to southeast into the White River.

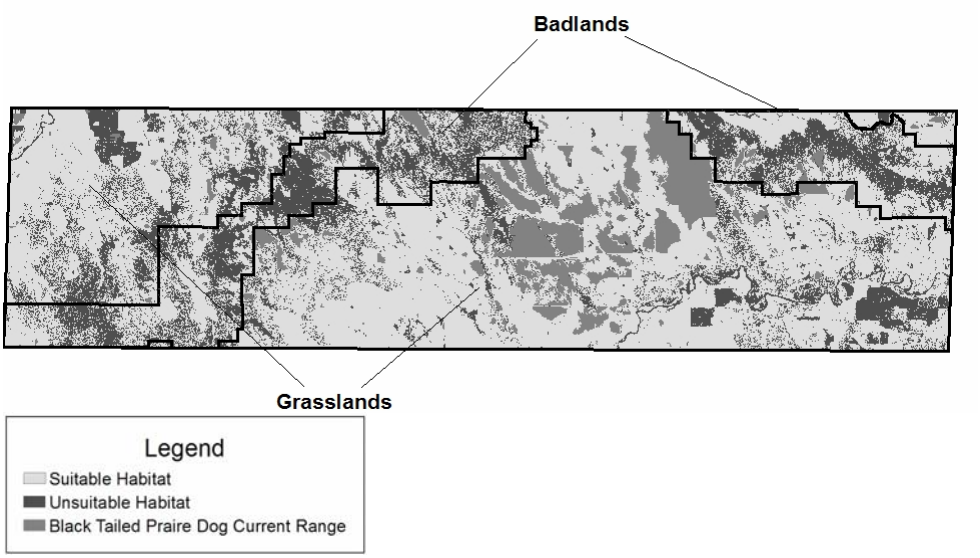

Figure 1. Map of the 400-square mile (103,767 hectare) study area in South Dakota. The study area includes portions of Badlands National Monument and a Livestock Grazing Complex that includes a combination of U.S. Forest Service Buffalo Gap National Grasslands, Pine Ridge Indian Reservation, and private lands.

Vegetation on the Livestock Grazing Complex is a relatively uncomplicated mixture of shortgrass species, dominated by buffalograss (*Buchloe dactyloides)*,blue grama (*Bouteloua gracilis*) and sedges (*Carex* spp.) along with annual and perennial forbs. Mid-grasses such as western wheatgrass (*Agropyron smithii)* and needlegrass *(Stipa viridula*) probably formed a major component of the historical plant species composition (Kuchler l964) and occur primarily in isolated, remnant stands. In contrast, the lightly grazed rangelands on BNM are dominated by midgrasses. The abrupt vegetation interface between the BNM and Livestock Grazing Complex is attributed to the influence of sustained moderate to heavy livestock grazing on the Livestock Grazing Complex.

Climatic conditions on the study area are continental. Late summer (July-August) diurnal temperatures often exceed 38^{o}C, and in winter temperatures are often well below freezing. Precipitation is normally between 38 and 43 cm annually, most falling as rain in spring and summer showers. Annual precipitation measured in Interior, South Dakota during the study was: 1974-27.0 cm; 1975-36.9 cm; 1976-31.9 cm; 1977-52.9 cm; and 1978-50.7 cm.

Remote Sensing Mission

Vertical imagery for illustrating annual changes in black-tailed prairie dog colony dynamics was obtained from two sources. Base year black-and-white photographs were obtained from the Agriculture Stabilization and Conservation Service (ASCS) for l968. This series of 23 x 23 cm, 1:20,000 scale photographs was used to assess the accuracy and repeatability of the interpretative procedures, to develop and standardize imagery scanning procedures, and to provide the initial data set on colony dynamics. Missions to acquire vertical imagery were flown in May and September of l974 at scales of 1:20,000 (2.54 cm = 508 m) and 1:15,840 (2.54 cm = 402 m), respectively, to determine which time period-scale combination provided greater contrast and target resolution. From l975 to l978, all missions were flown at 1:15,840 because it was easier to define the

interface between areas occupied and unoccupied by prairie dogs on the larger scale prints. Missions were flown during September based on observations that black-tailed prairie dog populations tend to stabilize socially and spatially for the year by late summer and early fall (July to September), with few changes in area occupied by colonies until the following spring and early summer (King l955). All missions were flown and imagery processed by a company specializing in aerial photography and conventional and digital photogrammetry. Flight protocol, aerial photograph processing, and map processing were described in Tietjen et al. (l978). Missions were flown at an altitude of 2414 m above ground level under cloudless conditions. The resulting high contrast black-and-white photographs were scanned with a mirror stereoscope to determine the presence of prairie dog colonies, which register as groupings of white dots representing soil mounds. Colonies were outlined on the photographs with a fine ink pen by connecting peripheral mounds, and the colony outline transferred to 1:24,000 scale U.S. Geological Survey topographic maps using a variable scale reflecting projector. The acreage occupied by an individual prairie dog colony was measured from the outline on the topographic map using a disc roller planimeter calibrated to 0.04 ha. For final presentation, colonies were transposed to 1:126,720 (1 cm = 1.3 km) scale Class A Forest Service recreation maps. Colonies in close proximity were classified as separate entities if the interface on 1:15,840 scale prints exceeded 50 m at its narrowest point, or if groups of mounds were completely separated by a physical barrier that interrupted direct interaction between prairie dog populations.

For 1968 and 1974-l978 the following data bases were derived for the entire study area and for the Livestock Grazing Complex and the BNM (ungrazed by livestock): (1) total number of colonies present (data on Livestock Grazing Complex and the BNM include exclusive colonies and those intruding from the adjacent area); (2) colony size distribution; (3) percent of gross land area occupied by colonies; (4) colony assimilation profile (assimilation refers to prairie dog colonies that existed as separate entities at one time but were absorbed by other, more dynamic colonies during the study); (5) colony life span (for colonies that existed as separate entities at one time but were unsuccessful and disappeared during the study); and (6) spatial distribution of colonies in relation to surface drainage patterns, topography, and cultural features.

The calculation of annual variation in scale of aerial photographs was based on a sample of 5-6 linear measurements of permanent landmarks (section lines or roadways) for each of 7 flight-lines to give 40 repeated measurements for each year. Aerial photograph scale was calculated using the formula:

$$\text{Photo Scale} = \frac{\text{Distance (m) on Photo}}{\text{Distance (m) on Map}} \times \text{Map Scale}$$

Ground Truth.

Ground truth studies were implemented to measure the degree of interpretive error and to determine if prairie dog colonies could be consistently found regardless of size, shape, and location. Ground information was collected on 40 pre-selected colonies during a 2-year period (18 colonies in l977 and 22 in 1978) immediately following the annual flight missions. We measured a linear distance (along a fence-line, trail, or roadway) between a well-defined initial point and the last observed peripheral mound on the edge of a prairie dog colony. This straight line distance was first measured on vertical imagery to the nearest 0.004 cm (0.001 in) with a vernier caliper, then

converted by scale (2.54 = 402 m) to the nearest 0.1 m. These measurements were then duplicated in the field using a vehicle-mounted Model 660 rolatape measuring wheel calibrated at 2.01 m (6.6 ft) per revolution. Mean linear distance was derived from an average of two runs along the same line. Estimated error was based on variance between image and ground distance expressed in linear terms (to nearest 0.1 m), and percent (±) of total distance on the ground.

Analysis of Area Suitable for Grazing on Livestock Grazing Complex and on BNM.

Suitable area for grazing was determined for both the BNM and the Livestock Grazing Complex through use of United State Department of Agriculture/National Resource Conservation Service Land Use Land Cover data. Data on the 400 square-mile (1,036 km^2) study area were extracted from this data base (http://datagateway.nrcs.usda.gov) using MicroImages GIS and ESRI ArcGIS software. A 30-meter pixel size was used and 12 categories were used to describe the habitat (open water, residential/commercial, bare rock/sand/clay, deciduous forest, evergreen forest/mixed forest, grassland/herbaceous, pasture/hay, row crops, small grains, fallow, woody wetlands, emergent herbaceous wetlands). Habitat categories considered suitable for grazing were grassland/herbaceous and pasture/hay (Table 1, Figure 1).

Table 1. Area (ha) and percentage of habitat within the Badlands National Monument and the Grasslands Complex included within each of 12 habitat categories. The Livestock Grazing Complex includes a combination of U.S. Forest Service Buffalo Gap National Grasslands, Pine Ridge Indian Reservation, and private lands.

	Badlands National Monument		Grasslands Complex	
Habitat Category	Area (ha)	% of Habitat	Area (ha)	% of Habitat
Open water	19.35	0.077	680.49	0.866
Residential/commercial	0	0	4.59	0.006
Bare rock/sand/clay	10867.86	43.088	8779.23	11.0
Deciduous forest	.81	0.003	21.96	0.028
Evergreen forest/mixed forest	6.39	0.025	71.82	0.091
Grassland/herbaceous[1]	13969.53	55.386	62459.1	79.303
Pasture/hay[1]	181.62	0.720	2167.38	2.759
Row crops	62.64	0.249	950.85	1.210
Small grains	105.84	0.420	2377.80	3.027
Fallow	0	0	806.04	1.026
Woody wetlands	0	0	34.74	0.442
Emergent herbaceous wetlands	8.28	0.033	190.62	0.242
Totals	25222.32	100.00	78544.62	100.00

[1] **This habitat is considered suitable for grazing by cattle**

Statistical Analysis.

Two-way analysis of variance (ANOVA) was used to examine differences among years for the Livestock Grazing Complex and the BNM. The response variables used in the analyses were: (1) number of prairie dog colonies per unit of total area; (2) number of colonies per unit of suitable grazing area; (3) average colony size; (4) proportion of total area occupied by prairie dog colonies; and (5) proportion of area suitable for livestock grazing occupied by prairie dog colonies. For significant effects, Duncan's multiple range procedure was applied to determine which means were significantly different. A paired t-test was used to compare the response variables between the BNM (grazed by wildlife only) and the Livestock Grazing Complex (grazed by livestock). The nonparametric Kolmogorov-Smirnov test was used to analyze for pairwise differences in colony size distribution for the following: (1) Livestock Grazing Complex l974 vs l978; (2) BNM l974 vs l978; and (3) BNM vs. Grasslands Complex for each year.

RESULTS

Aerial Photography Technique

Aerial photography proved to be a useful technique for plotting the size and expansion rate of prairie dog colonies (Tietjen et al. l978). Colonies down to 0.1 ha were consistently located on the study area using 1:15,840 scale high contrast 23 x 23 cm panchromatic contact prints, and following transposition to 1:24,000 scale topographic maps, area occupied by colonies were estimated with a 3.1% mean error. These observations indicated that the technique was repeatable enough to detect changes in colony dynamics (number, size, and distribution) and provide an indirect measurement of prairie dog population dynamics.

The average scale on the aerial photographs (1974-1978) was 2.54 cm = 424 m or 1:16,693. Scale variation was probably related mainly to altitude flown. Because the error amounts to little more than 5%, we made no effort to correct for it in calculating areas occupied by prairie dogs. There were no significant differences between surface distance and aerial photo distance measurements using either the paired t-test or the Wilcoxon signed-rank non-parametric test. The mean percentage difference between the two measurements was 4.3 % (SE = 0.4; range = 0.3-11.7).

Annual Trends in Colony Numbers, Size, and Spatial Distribution

This 10-year comparison of aerial photographs shows dramatic increases in prairie dog colony numbers and acreage occupied. The number of colonies increased on the combined study area from 121 in 1968 to 586 in 1978 (Table 2, Figure 2) and the amount of area occupied increased from 1,347 ha to 14,585 ha.

Livestock Grazing Complex. The number of prairie dog colonies on the Livestock Grazing Complex increased from 110 in l968 to 344 in l974 and to 508 in l978 (Table 1). The total area occupied by colonies (and percent of gross land area occupied) were 1,153.8 ha (1.5 %) in l968, 5,889.5 ha (7.5 %) in 1974, and 14,022.9 ha (17.8 %) in l978. Average colony size increased from 10.5 ha in l968 to 17.1 ha in l974 and 27.6 ha in l978. By l978, 173 colonies present in earlier years had been assimilated into larger colonies. There were significant differences ($P < 0.01$) between years for the Livestock Grazing Complex in the number of colonies present and average colony size. The number of colonies in the Livestock Grazing Complex increased significantly between 1968 and 1974, then remained the same from 1975 to 1978 (no significant increase in number of colonies after l974). Average colony size increased significantly from l968 to l974, was

stable through l977, then increased again between 1977 and l978.

Table 2. Comparison between the Livestock Grazing Complex and the Badlands National Monument, 1968 through 1978 for: 1) number of prairie dog colonies present; 2) hectares of study area occupied by prairie dog colonies; 3) percent of study area occupied by prairie dog colonies; 4) percent of area suitable for grazing by cattle that is occupied by prairie dog colonies; 5) average prairie dog colony size; and 6) number of colonies assimilated by other colonies since the previous year. The Livestock Grazing Complex includes a combination of U.S. Forest Service Buffalo Gap National Grasslands, Pine Ridge Indian Reservation, and private lands.

	1968	1974	1975	1976	1977	1978
Total No. Colonies Present						
Livestock Grazing Complex	110	344	489	575	593	508
Badlands National Monument	11	32	42	66	72	78
Total Area Occupied (Ha)						
Livestock Grazing Complex	1153.8	5889.5	7338.5	9307.4	1874.7	14022.9
Badlands National Monument	193.0	324.4	337.6	396.9	495.2	562.3
Percent of Gross Land Area Occupied						
Livestock Grazing Complex	1.5	7.5	9.3	11.8	15.1	17.8
Badlands National Monument	0.8	1.3	1.3	1.6	2.0	2.2
Percent of Grazable Area Occupied						
Livestock Grazing Complex	1.8	9.1	11.4	14.4	18.4	21.7
Badlands National Park	1.4	2.3	2.4	2.8	3.5	4.0
Average Colony Size (Ha)						
Livestock Grazing Complex	10.5	17.1	15.0	16.2	20.0	27.6
Badlands National Monument	17.6	10.1	8.0	6.0	6.9	7.2
No. Colonies Assimilated Since Previous Year						
Livestock Grazing Complex		16	55	96	148	173
Badlands National Monument		0	1	2	11	5

Of the 78,544.6 ha included in the Livestock Grazing Complex, 82.3% (64,624.8 ha) was considered to be suitable for grazing based on the United State Department of Agriculture, National Resource Conservation Service Land Use Land Cover data. The percentage of the area suitable for grazing that was occupied by prairie dogs increased between years, from 1.8% in 1968 to 9.1 % in 1974, and to 21.7% in 1978 (Table 2). There were significant differences ($P < 0.01$) between years for the Livestock Grazing Complex in the percentage of total and net suitable grazing area occupied by prairie dog colonies.

Colonies present in each year were grouped according to size and placed in 13 size classes (Table 3), ranging from the smallest class (0.1-1 ha), to the largest class (2048.1-4096 ha). In 1968 there were no colonies on the Livestock Grazing Complex larger than 256 ha. By 1974, the largest colony was in the 512.1-1024 ha class. From 1975 through 1978, the largest colony was included in the 1024.1-2048 ha class, and by 1978, one colony was in the 2048.1-4096 ha class. There was a significant difference ($P < 0.01$) between years in the colony size distribution for the Livestock Grazing Complex, with greater numbers of colonies in the larger classes in l978 than in 1968 and l974 (Table 3, Figure 3).

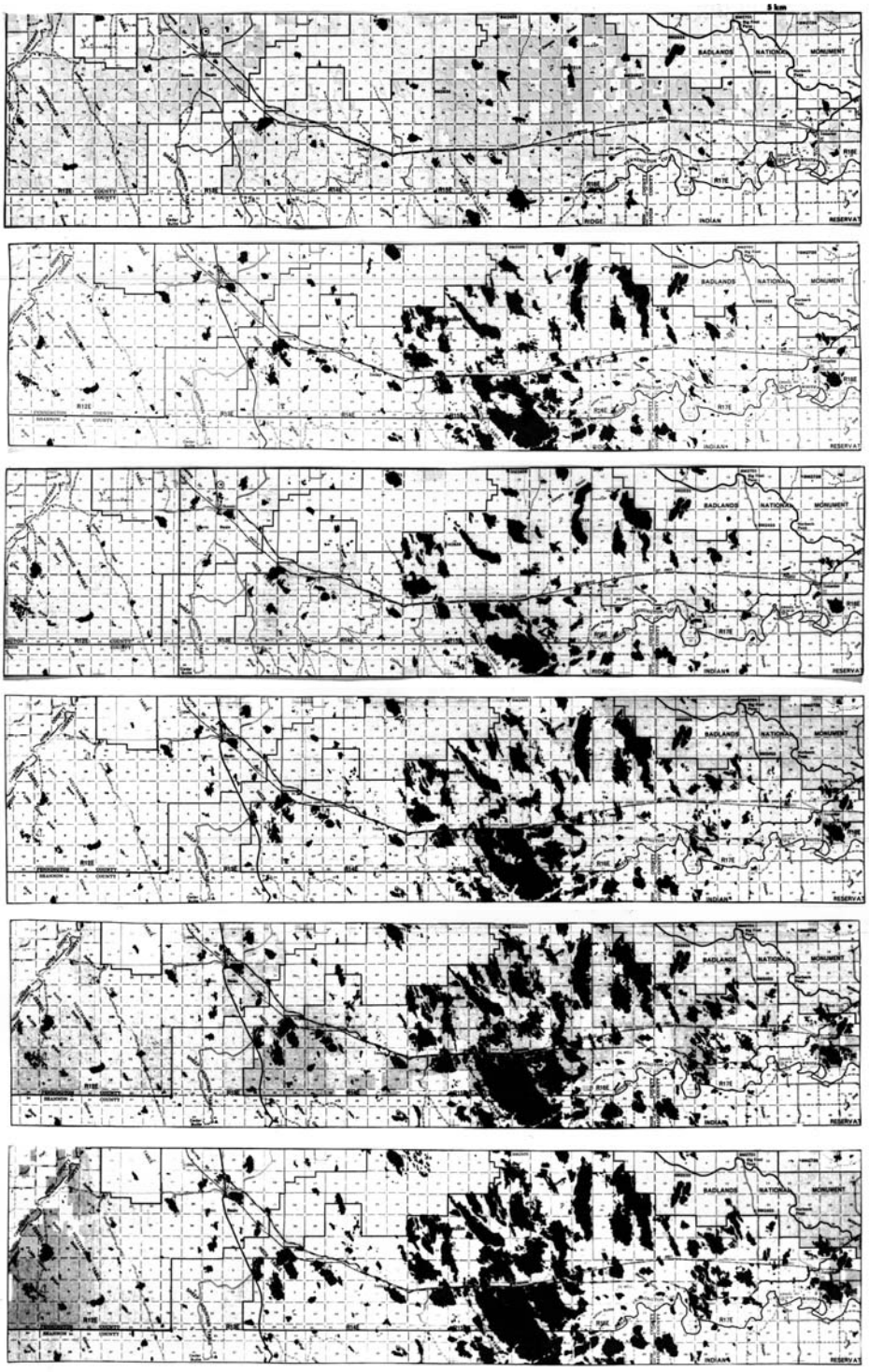

Figure 2. Black-tailed prairie dog (*Cynomys ludovicianus*) colony expansion on a 400 mile^2 (1,036 km^2) area of South Dakota including Badlands National Monument and Buffalo Gap National Grassland between 1968, 1974, 1975, 1976, 1977 and 1978 (top to bottom). Colonies are shown in black; each square represents 1 mile^2 (2.6 km^2).

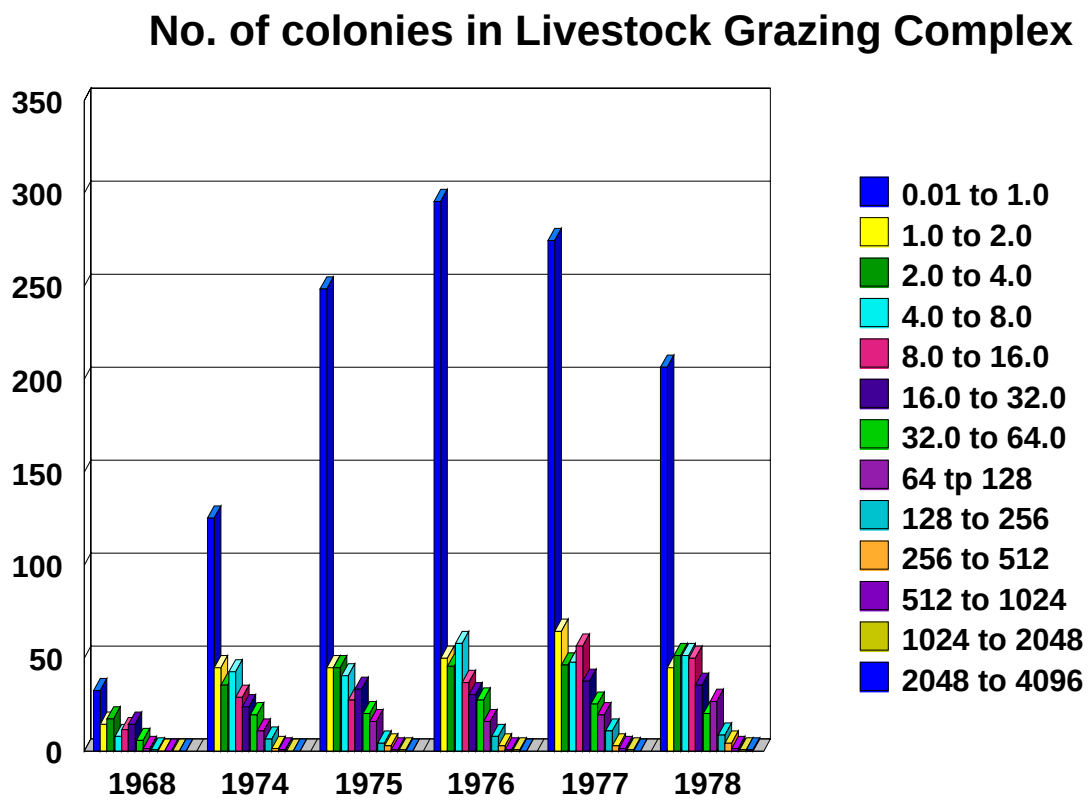

Figure 3. Distribution of number of colonies by year within the Gassland Complex for each of 13 size classes (hectares).

Badlands National Monument. The number of colonies on the BNM increased from 11 (7 exclusive and 4 intrusive from the Grassland) in l968 to 32 (18 exclusive and 14 intrusive) in l974 and to 78 (58 exclusive and 20 intrusive) in l978 (Table 2). Five colonies present in earlier years had been assimilated by larger colonies by l978. The total area occupied by colonies (and percent of gross land area occupied) was 193.0 ha (0.8 %) in l968, 324.4 ha (1.3 %) in l974, and 562.3 ha (2.2 %) in l978. Average colony size decreased from 17.55 ha in l968 to 10.14 in l974 and 7.21 ha in l978. As on the Livestock Grazing Complex, colonies were grouped by size distribution (Table 3). There was a significant difference ($P < 0.01$) between years in the colony size distribution on the BNM (Table 3, Figure 4), with the number of small colonies (sizes 0.1-2 ha) increasing over years.

Table 3. Number of colonies and percentage of total land area occupied by prairie dogs within each colony size class on the Livestock Grazing Complex and the Badlands National Monument.

Colony Size	1968		1974		1975		1976		1977		1978	
(Hectares)	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Livestock Grazing Complex												
0.1-1	33	1.4	126	0.9	249	1.0	296	0.9	275	0.7	207	0.5
1.1-2	15	1.8	45	1.1	45	0.9	50	0.8	65	0.8	45	0.4
2.1-4	18	4.4	36	1.8	45	1.7	46	1.4	47	1.2	52	1.0
4.1-8	8	3.9	43	4.5	41	3.3	58	3.6	48	2.2	52	2.1
8.1-16	12	12.2	29	5.5	28	4.4	37	4.3	57	5.4	50	4.1
16.1-32	15	29.8	24	9.4	34	10.1	31	7.6	38	7.2	36	5.5
32.1-64	6	20.0	20	15.2	21	12.5	28	13.3	26	10.2	21	6.6
64.1-128	2	11.7	11	15.4	16	19.1	16	16.0	20	14.9	27	17.3
128.1-256	1	14.8	7	21.2	5	11.3	8	15.2	11	15.4	9	11.1
256.1-512	0	0	2	10.5	3	12.1	3	11.6	3	7.8	5	12.4
512.1-1024	0	0	1	14.6	1	7.0	1	6.7	2	12.7	2	10.4
1024.1-2048	0	0	0	0	1	16.6	1	18.6	1	21.6	1	8.8
2048.1-4096	0	0	0	0	0	0	0	0	0	0	1	19.7
Badlands National Monument												
0.1-1	2	0.6	8	1.2	13	2.1	24	2.0	24	1.9	30	2.9
1.1-2	0	0	1	0.6	3	1.5	7	3.0	7	2.5	10	3.5
2.1-4	1	1.5	1	1.3	1	0.9	2	1.8	4	3.0	5	3.9
4.1-8	0	0	2	3.6	2	3.9	4	7.8	1	1.3	4	6.5
8.1-16	1	7.9	1	4.8	1	4.2	1	3.6	5	16.5	5	15.2
16.1-32	1	19.1	2	16.8	2	14.4	2	13.2	1	7.5	1	6.9
32.1-64	1	28.3	1	13.0	1	14.3	1	12.8	1	11.8	1	10.1
64.1-128	1	42.5	2	58.7	2	58.7	2	55.7	2	55.4	2	51.0

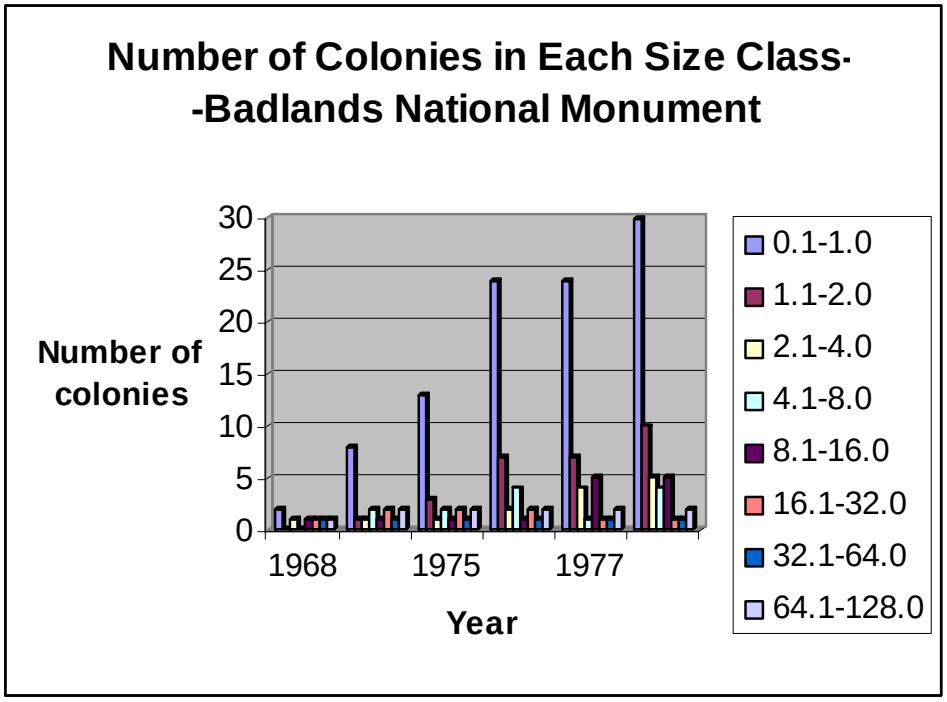

Figure 4. Distribution of number of colonies by year within the Badlands National Monument for each of 13 size classes (hectares).

Of the 25,222.3 ha included in the BNM, 56.1% (14,151.1 ha) was considered to be suitable for livestock grazing based on the United State Department of Agriculture, National Resource Conservation Service Land Use Land Cover data. The percentage of the area suitable for livestock grazing that was occupied by prairie dogs increased slightly between years, from 1.4% in 1968 to 2.3% in 1974, and 4.0% in 1978 (Table 2). This was a significantly smaller increase than that on the Livestock Grazing Complex.

There was a significant difference between the Livestock Grazing Complex and the BNM in percent of the total area occupied by prairie dogs, in percent of the suitable grazing area occupied by prairie dog colonies ($P < 0.01$), and in average colony size ($P = 0.05$). There was also a significant difference in colony size distribution between the Livestock Grazing Complex and the BNM ($P < 0.01$) in every year but l968 (Table 3, Figure 3, Figure 4).

DISCUSSION

The application of remote sensing techniques to studies of prairie dog colony dynamics is not new. Aerial photographs were used intermittently in Wind Cave National Park between l938 and l952 to follow changes in areas occupied by prairie dogs and distribution of burrows in a few colonies (King l955, Koford l958). Lovaas (l973), Cheatheam (l973, l977), Grondahl (l973), Hinckley and Crawford (l973), Lewis and Hassein (l973), and Rose (l973) all reference use of aerial surveys in management programs to determine distribution and numbers of prairie dog colonies on state and federal lands. Bishop and Culbertson (l976) used aerial photographs to illustrate reductions in size, number, and distribution of black-tailed prairie dog colonies in North Dakota during l939-l972. Rekas (l978) plotted active and inactive colonies, described specific habitat conditions on colony sites and

identified potential habitat for prairie dogs. Dalsted et al. (l981) concluded that 1:15,840 scale vertical imagery was a valuable aid for inventories of expanding prairie dog colonies. In this study, aerial photography proved to be a useful technique for detecting changes in colony numbers, size, and distribution.

This study showed that prairie dog colonies expanded rapidly between 1968 and 1978 on the Livestock Grazing Complex. The land area occupied by prairie dogs increased from 1154 ha (1.5% of the area) to 14,023 ha (17.8% of the land area) and the number of colonies increased from 110 to 508, with many colonies assimilated during this period. Other studies support our observations. Knowles (l982) reported an intrinsic rate of growth (r) for colonies of 0.412 and Stockrahm (1979) an r = .5. Knowles (l982) found that notable dispersal occurred during periods of drought following one or more years of abundant precipitation (not observed during this study). He proposed that expansion appeared to be a response to balance numbers of prairie dogs with available forage. In our South Dakota study area, precipitation averaged between 38 and 43 cm per year; the middle years of this study (1973 – 1976) had reduced rainfall, which probably facilitated short vegetation. King (l955) found that colony expansion occurred in the years with lots of pups and poor growth of grasses during spring.

Prairie dog colony growth was significantly lower on the ungrazed BNM than on the Livestock Grazing Complex, indicating that livestock grazing increased the rate of colony expansion. On the Livestock Grazing Complex, prairie dog colonies increased at the average rate of 32.8% per year between 1968 and 1978. The rate of increase was 38.5% between 1968 and 1974. In subsequent years it was: 24.6%-1974 to 1975; 26.8%-1975 to 1976; 27.6%-1976 to 1977; and 18.1%-1977 to 1978. On the Badlands National Monument, the average annual rate of increase was only 12.5%. The annual rate of increase was: 10.9%-1968 to 1974; 4.1%-1974 to 1975; 17.6%-1975 to 1976; 24.8%-1976 to 1977; and 13.5%-1977 to 1978. Figure 2 shows that by 1978 many colonies expanded on the BGNG, but few expanded onto the Monument itself, even though the fence separating the two areas was only barbed wire. The mid-grasses of the National Monument seemed to be an effective barrier, slowing colony expansion.

Other studies have found that prairie dogs most frequently colonize sites that have been overgrazed or otherwise disturbed (Koford l958, Smith 1967, Hanson 1993, and Fagerstone and Ramey 1996), and are a result rather than a cause of poor range condition. Knowles (l982) found most prairie dog colonies associated with livestock watering areas or homestead sites, an observation also made by Reid (l954), Koford (l958), Hillman et al. (l978), and Dalsted et al. (l981). Knowles (l982) also reported a high occurrence of roads and trails in colonies. Prairie dogs are thought to be associated with rangelands in poor condition and with intensive grazing by large ungulates, including bison (Mead l898, Reid l954, King l955, Koford l958, Smith l967, Hassien l976, Coppock et al. l983 a,b, Fagerstone and Ramey 1996). Uresk et al. (l981) also found prairie dogs more abundant in areas grazed by cattle than in areas where cattle were excluded.

Prairie dog colony establishment and expansion can be minimized by controlling placement of stock watering areas, and by modifying stocking rate and seasonal patterns of use by livestock (Knowles l982). Knowles (l982) also suggested that providing periodic rest to a pasture may prevent the establishment of prairie dogs at stock watering areas. Snell and Hlavachick (l980) believed that initiation of a deferred grazing system in a 45-ha dog colony caused the colony to decline to 6 ha within 3 years. Uresk et al.

(l981) suggested that periodic exclusion or reducing cattle stocking rates may help regulate prairie dog population densities. Mead (l898) found prairie dogs in Kansas disappeared rapidly in the absence of bison. Osborn and Allan (l949) reported the disappearance of a prairie dog colony within 10 years of removal of cattle and Knowles (l982) found that of three colonies where grazing had not occurred for 7 to 10 years, one was inactive and two were greatly reduced in size.

Tall and vigorous growths of grasses deter prairie dogs (Allan and Osborn l954), possibly by putting prairie dogs at a disadvantage in detecting predators. Greater cattle use of prairie dog colonies has been observed by Knowles (l982) and Hassien (l976), a factor that increases effects on vegetation.

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